

**Teacher’s Guide**

**The Chemistry of Deception**

***December 2022***

**Table of Contents**

[***Anticipation Guide***](#_heading=h.1fob9te)***2***

Activate students’ prior knowledge and engage them before they read the article.

[***Reading Comprehension Questions***](#_heading=h.3znysh7) ***3***

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[***Graphic Organizer***](#_heading=h.9f8azrtnp6p5) ***5***

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[***Answers***](#_heading=h.djipzn7z1r1b) ***6***

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[***Additional Resources***](#_heading=h.8qbtv1wio6jt) ***9***

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article

***[Chemistry Concepts and Standards](#_heading=h.gy1yjx1c39og) 10***



# Anticipation Guide

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Lemon juice was used by German spies during World War I to send secret messages. |
|  |  | 2. Milk, fruit juices, and human body fluids have all been used to send secret messages. |
|  |  | 3. Revolution spies in George Washington’s time developed a new type of invisible ink. |
|  |  | 4. Tannic acid contains iron. |
|  |  | 5. Tannic acid is found in tea, coffee, chocolate, and bitter other foods. |
|  |  | 6. Cellulose is a polysaccharide. |
|  |  | 7. Incomplete combustion of carbon compounds produces carbon dioxide. |
|  |  | 8. German spies used an antiseptic containing silver to create invisible ink. |
|  |  | 9. Ultraviolet (UV) light has a longer wavelength than the light we can see. |
|  |  | 10. Invisible UV inks must be viewed with a UV light. |

# Student ReadingComprehension Questions

**Directions**: Use the article to answer the questions below.

1. What common citrus fruit was used in early spy missions to create invisible messages? What did the reader have to do to reveal the hidden secret?
2. Discuss the chemical composition of the “magical white ink” used by George Washington during the American Revolution. Explain how the ink was “developed” so the recipient could read the message.
3. Explain the process of chelation. Discuss a real world use of chelation in the medical field.
4. Explain how lemon juice browns faster when subjected to heat than the paper it is written on.
5. The Germans' secrets for developing silver invisible ink were unfortunately lost over time. Discuss the process French scientists derived to reveal messages written with silver based invisible ink.
6. How do ultraviolet invisible inks work?
7. The article mentions electrolysis as a means of developing secret messages written with silver invisible ink. Discuss electrolysis and some common uses of electrolysis.
8. A portion of the electromagnetic spectrum is shown on page 17. Discuss the wavelength, frequency, and uses of 3 of the 7 types of electromagnetic radiation on the diagram at the top of the page.
9. The article discusses how bonds in the tannic acid structure resonating between single and double bonds affect energy absorption and thus are responsible for the color of the compound. Resonating single and double bonds causes electrons to be “delocalized” inside the molecule. Define delocalized electrons and list some properties associated with molecules containing delocalized electrons.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. War, despite its horrors, often accelerates progress and innovation. Many of the technologies we enjoy today were invented in a time of war due to a nation trying to secure victory. Make an infographic discussing at least 5 technologies or innovations that were developed or invented during a time of war.
2. Now it’s your turn! Attempt to make an encrypted message using either a mysterious alphabet, pattern, or invisible ink. If invisible ink supplies are available such as lemon juice or other chemicals be sure to follow safety precautions presented by your teacher. Give your message to a friend or partner with instructions on how to “develop” the message. If you create a message using a pattern, mysterious alphabet, puzzle, or other technique, give your message to a friend or partner and see if they can crack the code! Please keep the hidden messages appropriate and kind!

# Graphic Organizer

**Directions**: As you read, complete the graphic organizer below to describe how invisible inks work.

|  |  |  |
| --- | --- | --- |
| **Type of Invisible Ink** | **Chemicals (or ingredients) involved** | **How the message is made visible** |
| **Milk** |  |  |
| **Magical White Ink** |   |  |
| **Lemon Juice** |   |  |
| **Silver Invisible Ink** |   |  |
| **Ultraviolet Invisible Ink** |  |  |

**Summary:** On the back of this sheet, write a short email (3-4 sentences) to an older relative describing what you learned about invisible inks.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. What common citrus fruit was used in early spy missions to create invisible messages? What did the reader have to do to reveal the hidden secret?

Lemons, lemon juice, were used to create invisible messages by the Germans in World War 1. The invisible message could be revealed by applying heat to the paper, darkening the ink.

1. Discuss the chemical composition of the “magical white ink” used by George Washington during the American Revolution. Explain how the ink was “developed” so the recipient could read the message. Tannic acid was the primary component of the magical white ink. The ink could be developed using Iron (II) Sulfate which darkened the message through a process called chelation.
2. Explain the process of chelation. Discuss a real world use of chelation in the medical field.

Chelation involves organic molecules surrounding a metal atom by bondings at several points. Chelation is used by doctors to extract heavy metals from the body.

1. Explain how lemon juice browns faster when subjected to heat than the paper it is written on.

Lemon juice contains simple sugars and acids that combust more rapidly than the complex polysaccharides that are found in paper.

1. The Germans' secrets for developing silver invisible ink were unfortunately lost over time. Discuss the process French scientists derived to reveal messages written with silver based invisible ink.

The message was placed in a medium of silver nitrate with a reducing agent which serves as an electron donor. Electricity is applied to the medium which causes silver metal to be plated where the message was written making it visible. The process is known as electrolysis.

1. How do ultraviolet invisible inks work?

Ultraviolet light is not visible to the human eye. Ultraviolet markers can be used to write a message that can only be read when exposed to ultraviolet light which will cause the message to glow with fluorescent light.

1. The article mentions electrolysis as a means of developing secret messages written with silver invisible ink. Discuss electrolysis and some common uses of electrolysis.

Answers may vary. Example answer: Electrolysis is the process of using electricity to drive a nonspontaneous process or chemical reaction, particular redox reactions. Electrolysis can be used to plate metals on other metals for various purposes or products.

1. A portion of the electromagnetic spectrum is shown on page 17. Discuss the wavelength, frequency, and uses of 3 of the 7 types of electromagnetic radiation on the diagram at the top of the page.

Answers may vary. Example answer: X-rays have a wavelength of 10-8 to 10-12 meters and a frequency of 1016  to 1020 hertz. X-rays can be used to take images of bones and hard tissue inside the body.

1. The article discusses how bonds in the tannic acid structure resonating between single and double bonds affect energy absorption and thus are responsible for the color of the compound. Resonating single and double bonds causes electrons to be “delocalized” inside the molecule. Define delocalized electrons and list some properties associated with molecules containing delocalized electrons.

Delocalized electrons are electrons in a molecule that are not associated with a single atom or covalent bond. They are able to flow or move within the molecule. Delocalized electrons give molecules the ability to conduct electricity and/or be malleable, such as metals.

1. War, despite its horrors, often accelerates progress and innovation. Many of the technologies we enjoy today were invented in a time of war due to a nation trying to secure victory. Make an infographic discussing at least 5 technologies or innovations that were developed or invented during a time of war.

Answers may vary. Examples are radar, penicillin, computers.

1. Now it’s your turn! Attempt to make an encrypted message using either a mysterious alphabet, pattern, or invisible ink. If invisible ink supplies are available such as lemon juice or other chemicals be sure to follow safety precautions presented by your teacher. Give your message to a friend or partner with instructions on how to “develop” the message. If you create a message using a pattern, mysterious alphabet, puzzle, or other technique, give your message to a friend or partner and see if they can crack the code! Please keep the hidden messages appropriate and kind!

Answers may vary.

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

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# Additional Resources and Teaching Strategies

**Additional Resources**

* **Labs and demos**
	+ Investigating Ink Lab Activity

<https://teachchemistry.org/classroom-resources/investigating-black-ink>

* + Homemade Invisible Ink Activity

<https://teachchemistry.org/classroom-resources/top-secret>

* **Lessons and lesson plans**
	+ Electrolysis Lesson

<https://teachchemistry.org/classroom-resources/exploration-of-electrolytic-cells>

* + Delocalized Electrons and Material Science Article

<https://teachchemistry.org/periodical/issues/may-2022/bringing-materials-chemistry-into-the-teaching-of-bonding>

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students if they have used invisible ink to send secret messages. Also ask them who might find invisible ink useful, and how invisible inks might work. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
	+ As they read, students can find information to confirm or refute their original ideas.
	+ After they read, ask students what they learned about the varieties of invisible inks.
* After students have read and discussed the article, ask students what they learned about invisible ink and how it relates to other subjects, including history.

# Chemistry Concepts and Standards

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Physical properties
* Molecular structure
* Chemical change
* Electrolysis

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

**HS-ETS1-2.**  Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**Disciplinary Core Ideas:**

* PS.1.A: Structure and Properties of Matter
* PS.1.B: Chemical Reactions
* ETS1.B: Developing Possible Solutions

**Crosscutting Concepts:**

* Cause and effect
* Energy and matter
* Structure and function

**Science and Engineering Practices:**

* Constructing explanations (for science) and designing solutions (for engineering)

**Nature of Science:**

* Science is a human endeavor.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).